Coastal Aerosol Distribution by Data Assimilation

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LONG-TERM GOALS

The long-term goal of this research is to develop an initialization scheme for a multi-dimensional, predictive aerosol model in coastal regions. The initialization scheme will include data gathering, quality control and data assimilation of the available aerosol observations, including satellite radiances, ground-based remote sensing, point measurements, and the previous aerosol forecast.

OBJECTIVES

The objectives of this program are to (1) investigate and evaluate the existing and proposed aerosol retrievals from satellites for applicability to aerosol model initialization and (2) develop and test aerosol analysis and data assimilation techniques using satellite and other aerosol measurements.

APPROACH

The approach to the problem of aerosol and EO extinction prediction follows that used in numerical weather prediction, namely real-time assessment and first-principle modeling. The predictive model requires the initial spatial distribution of the aerosol field. Sensors and retrieval techniques exist for obtaining the aerosol optical depth and some information about particle size. The remotely sensed aerosol properties typically are vertical integrals and are generated at horizontal resolutions ranging from one kilometer to one degree. An objective analysis method will be devised to merge the 2-D distribution from remote sensing with point measurements and model constraints to produce a three-dimensional description of aerosol.

WORK COMPLETED

Programs to retrieve aerosol optical depth from AVHRR and GOES satellite data have been ported to NRL/MRY from NPS and will be implemented in FY1999. The theoretical basis behind the TOMS satellite aerosol retrieval scheme has been studied and codes have been developed to simulate the TOMS sensor and the NASA/GSFC retrieval scheme.

The global aerosol model has produced credible sulfate aerosol distributions, though validation is problematic in most regions of the world due to the low aerosol optical depths that go unnoticed by satellite retrievals. Including other aerosols, such as smoke or dust, will allow more extensive validation of transport since these aerosol are often more easily observed by satellite.

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RESULTS

The radiative transfer codes for TOMS data have been tested against theoretical limits and published reports by NASA/GSFC. The codes produce results that are in agreement with both theory and the literature. The codes will now be utilized to answer the question of where and when will the TOMS retrieval produce accurate results. We need to know both the error bars and the conditions where the retrieval fails.

Work was begun to expand the global sulfur aerosol model to include desert and smoke aerosols. This model will be used for spatial and temporal continuity between successive satellite overpasses. It is driven by NOGAPS meteorology and uses emission inventories for specifying the source of sulfate aerosol. Surface synoptic data have been analyzed to determine dust source regions for the entire globe. Programs for visualizing the global, multi-component, multidimensional aerosol data have been expanded to include dust and smoke aerosols (Figure 1).

IMPACT/APPLICATIONS

In the long term, the results from this research will allow the Navy to fulfill its goal of a predictive capability for aerosols and EO propagation. This research also provides tools for the 6.1 and 6.2 aerosol research communities and the academic community. Because of the difficulty and expense of in situ measurements, the satellite retrievals are essential to fundamental research into all aerosol systems, except at the smallest scales.

TRANSITIONS

In the near future, the analysis and retrieval techniques will provide real-time aerosol products showing the distribution of smoke, dust, volcanic ash and other aerosols that can be dissemination to the fleet for use in tactical, strategic and defense planning and used in EOTDA validation and development.

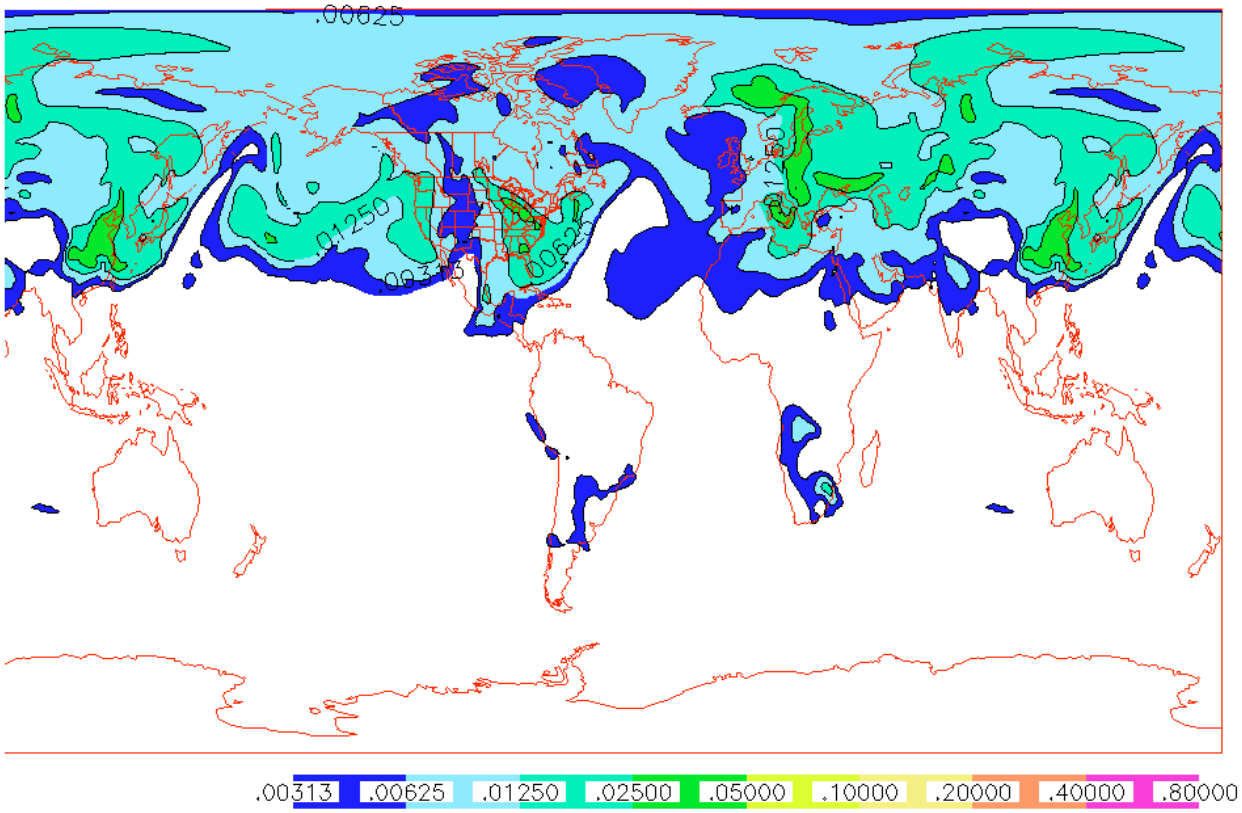
RELATED PROJECTS

The NRL 6.1 Coastal Aerosol Processes ARI and NRL 6.2 Weather On Target use the research-grade satellite retrievals for validation. When developed, the operational retrievals and the data assimilation product will be invaluable to these programs. This work is also relevant to 6.4 efforts in EOTDA evaluation and aerosol measurement.

IN-HOUSE/OUT-OF-HOUSE RATIOS

60% in-house, 40% out-of-house.

Figure 1. Next page. Top panel: NRL global aerosol model simulation of optical depth of sulfate aerosol valid at 00 UTC April 26, 1998. Note the model's ability to resolve synoptic eddies with intrusions of clean tropical air penetrating northward into the sulfate-rich mid-latitude air. The plume over the North Pacific and West Coast of the U.S. is from Chinese sources. Bottom panel: TOMS retrieval of aerosol amount (uncalibrated) for the same day as the top panel also showing a plume of aerosol over the North Pacific and the West Coast of the U.S. The aerosol is predominantly dust raised from the deserts of China on April 19. It was detected by the JPL lidar in Los Angeles at altitudes of 10 km on April 26. Though the two distributions represent aerosols of differing composition and origin, the similarities indicate that the global model has skill in simulating long-range transport at mid-latitudes driven by synoptic features. Explicit calculations of the dust transport will be done in FY99 along with development and testing of the aerosol analysis system.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